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Utilization of Brewery Spent Grain Liquor by *Aspergillus niger*[1]

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Aspergillus niger was found capable of rapidly converting about 97% of the sugar from brewery spent grain liquor to fungal mass. The yield of dry mycelium, based on the sugar consumed, was approximately 57%. This fungus produced 1.10% titratable acid calculated as citric acid and reduced the biochemical oxygen demand by 96%.

Spent grain liquor is one of the most significant sources of high-strength waste streams in the brewing industry. This liquor may account for 30 to 60% of the biochemical oxygen demand (BOD) and suspended solids generated by a typical brewery (8). To date, attempts to eliminate the spent liquor problem have not been successful. There is thus a need for development of methods for utilizing this wastewater.

Four yeasts and four mushrooms have been reported to grow well in brewery wastes (5). Although cell yields were satisfactory, reductions of BOD were only 20 to 45% in most cases. An industrially important fungus, *Aspergillus niger*, has been reported to convert rapidly a variety of substrates to useful products (4). The objective of the present study was to evaluate utilization of brewery spent grain liquor by this fungus.

Spent grain liquor was obtained from a nearby brewery; it contained the following, expressed as milligrams per liter: BOD, 22,500; reducing sugar as glucose, 23,000; Kjeldahl nitrogen, 335; total phosphorus, 86; total solids, 42,800; suspended solids, 336; pH 4.1. Experiments were conducted in 500-ml Erlenmeyer flasks containing 100 ml of spent grain liquor. The flasks were inoculated with 0.5 ml of a fungal spore suspension prepared by adding 10 ml of sterile distilled water to a 7-day-old slant culture. Flasks were incubated on a rotary shaker (200 rpm) at 30 C. Mycelial weight was determined by filtering, washing with distilled water, and drying at 105 C overnight. Analyses of 5-day BOD, Kjeldahl nitrogen, total phosphorus, and total and suspended solids were conducted according to the standard procedures (1). Titratable acid calculated as citric acid was determined by titrating 2-ml samples with 0.02 N NaOH using phenol-phthalein as an indicator. Reducing sugar was measured by the method of Clark (2). All samples were prepared in duplicate, and the reported data are average values.

Biochemical changes during fungal fermentation of spent grain liquor are depicted in Fig. 1. Sugar utilization increased rapidly in the first 72 h, and within 96 h approximately 97% of the sugar was consumed. Sugar utilization after 96 h was very slow, which may be due to the presence of slowly fermentable residual sugar in spent grain liquor.

A. niger produced a considerable amount of titratable acid calculated as citric acid (Fig. 1). Acid production increased rapidly in the first 48 h and reached a maximum of about 1.10% in 72 h. Concurrently, the pH dropped from 4.1 to a minimum of 2.4 at this time. Extending the fermentation beyond 72 h resulted in oxidation of citric acid by the fungus. It has been reported (3) that *A. niger* oxidized the accumulated citric acid upon exhaustion of the fermentable sugar. For this reason mainly, the industrial citric acid process is always stopped short of complete utilization of the sugar.

This fungus formed a spherical mycelium that could be easily harvested by filtration, and the filtrates were clear. This is considered to be a definite advantage of treating industrial waste effluents with fungi. Mycelial yield was about 13 g/liter of medium. Based on the sugar consumed, the yield of dry mycelium was approximately 57%. The recovered mycelium contained as much as 29% crude protein and might be used as a feed supplement.

The BOD was reduced from an initial value of 22,500 to 900 mg/liter, representing a reduction of about 96% (Fig. 2). Our data thus indicate that the utilization of brewery spent grain liquor by *A. niger* may have economic value in waste disposal and in the production of single-cell protein and citric acid.

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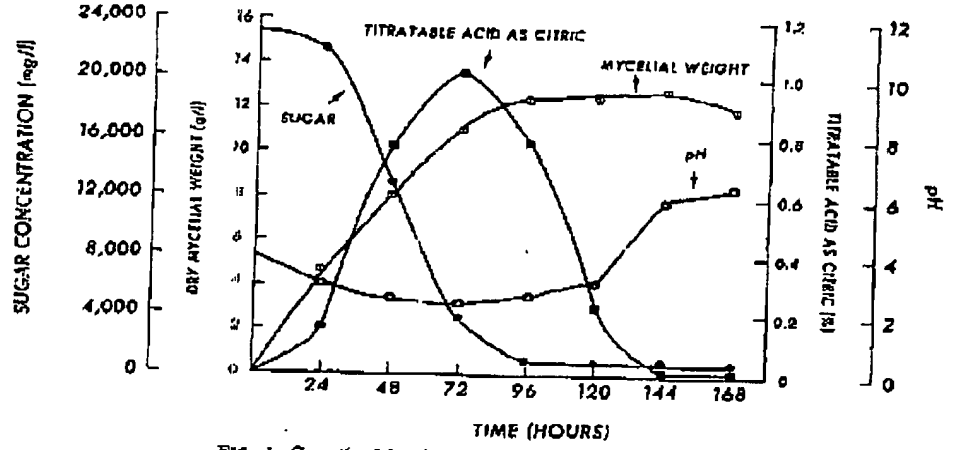

FIG. 1. *Growth of A. niger on brewery spent grain liquor.*

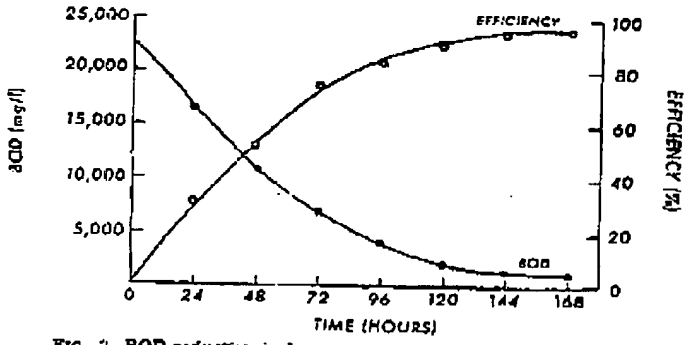

FIG. 2. *BOD reduction in brewery spent grain liquor by A. niger.*

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